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ABSTRACT

A randomly selected sample of a third year engineering class was instructed via CCMIT while the remainder of the class was instructed via the normal lecture model. The results of pre- and posttests used to evaluate the actual learning that occurred within both groups is described. Informal feedback information that reflects the responses of the students to the computer aided teaching mode is also discussed. The utility of computer aided teaching as learned from this experiment in a highly technical field is summarized. (Author/JEG)

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COMPUTER-AIDED TEACHING IN ENVIRONMENTAL ENGINEERING

by

Edward A. McBean

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COMPUTER-AIDED TEACHING IN ENVIRONMENTAL ENGINEERING

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Abstract: A randomly-selected sample of a third-year engineering class was instructed via COMIT while the remainder of the class was instructed via the normal lecture mode. The results of pre- and post-tests used to evaluate the actual learning that occurred within both groups, is described. As well, informal feedback information is discussed that reflects the responses of the students to the computer-aided teaching mode. The utility of computer-aided teaching as learned from this experiment, in a highly technical field, is summarized.

Introduction:

Biochemical oxygen demand (BOD) is a measure of the molecular oxygen required to stabilize the decomposable matter present in a water by aerobic biochemical action. A major portion of the decomposable matter in many water bodies is the sewage treatment plant outfall. In other words, BOD is an important metric used to partially characterize the strength of pollution loads.

Because oxygen is consumed in the decomposition/assimilation process, it is important to recognize the potential of excessive levels of BOD to deplete the oxygen levels within a receiving water body. The results of excessive oxygen consumption include fish suffocation and septic waters. Because of concerns such as those introduced above, the study of BOD represents a very important aspect of environmental engineering education. Nevertheless, unlike many chemical and physical reactions which can be observed in the laboratory within a duration of a few minutes of experimentation, the biological activity that occurs within the decomposition/assimilation of the BOD occurs with time, where time is measured in terms of days. This time span makes the laboratory analysis difficult to present to the student. Additional factors that suggest the considerable extent of the complexities within BOD determination are the dependence of the biological activity upon such concerns as the specific nature of the organic material,

the availability of micro-organisms, the availability of nutrients, and the temperature of the material. Because of considerations such as these, students have historically had difficulty understanding BOD and how it is exerted as a function of time.

As an alternative to the lecture presentation of the BOD-related material, the capabilities of COMIT to present the identical material was of interest. More specifically, a utilization of COMIT included the potential for employing its graphics capabilities to depict the laboratory analysis as a series of logical slides of the actions taken as a function of time in the laboratory procedure. As well, the mathematical characterizations of BOD exertion as a function of time are relatively difficult; it was felt that numerous examples and problems introduced within the COMIT presentation itself might enhance the familiarity of the student with the material, thereby increasing the learning effectiveness.

For the above reasons, a COMIT module was developed to encompass two lectures of the regular course taken by the third year engineering students at the University of Waterloo. Experiments were carried out with two successive classes of students wherein approximately forty students attended lectures in the normal manner and the randomly-selected group of about twenty were asked to attend only the COMIT proceedings.

As a means of evaluating the experiment utilizing COMIT, some feedback on the learning experience of the students was collected. This information is summarized in the paragraphs below by two different means: (1) formal - which consisted of pre- and post-examinations and (2) informal-information derived from discussions with the individuals involved with COMIT. Obviously, the formal means is the only output amenable to the numerical quantification, but it is also the one most susceptible to contamination of results.

Formal Characterization of Results

A considerable effort was expended to minimize the contamination of the results derived from the pre- and post-tests. Attention was given, for example, to ensure that no prior indication was given to the students about the tests that were to occur. The two classes which were utilized as observation groups were separated by an academic term to minimize the contamin-

ation that might result from an awareness of the experiences of the other class.

The testing of the students included a pre-test and two post-tests. All the tests were multiple choice and to the extent possible, were restricted to the material given specifically within the lecture and/or COMIT presentations.

The pre-test was given about two days before the lectures and COMIT presentations. The pre-test was given to establish their initial knowledge of the subject material specifically because some of the students may have had previous work experience dealing with concepts related to BOD and because some of the questions were somewhat logical, implying intelligent guesses were potentially fruitful. The results of the pre-test are indicated in Column I, Table 1. It is appropriate to note that purely random guessing would have attained a mean mark of about 3.2. A perfect mark on the test would have been 11.

Table 1

Results of Formal Testing

	I Pre-test	II COMIT	III Lectures
No. of individuals	60	16	42
mean	6.7	9.7	9.2
Standard deviation	1.35	0.8	1.2

About three days after the COMIT and lecture presentations the identical test was administered, the results of which are indicated in columns II and III, broken down as a function of group within the class (i.e. COMIT or lecture). It is noteworthy that a significant difference between the pre- and post-tests is apparent. Some of this apparent learning may have been guided or assisted by "recall" of the questions posed in the pre-test when subsequently the material was covered in the lecture and/or COMIT presentations. (It is not possible to separate this component of the learning that would have occurred within the two modes of presentation if there had been no pre-test, but the "recall" effect is probably quite minimal.) The most interesting aspect of the results contained in Table 1 is that there

is no significant statistical difference between the apparent learning experiences of the COMIT and the lecture mode participants.

A post-post exam (about 1½ months after the COMIT/lecture presentations) was also given, as a part of their final examination within the course. The questions posed in this examination were different from those of the previous multiple choice questions; however, the questions did deal strictly with that information that was given within the COMIT/lecture presentations. Again, there was no significant difference between the COMIT and lecture derived results (see Moore and McBean, 1978). Little weight can be assigned however, to this occurrence because through conversations with the students, it appears that there was significant interaction and discussion between the students suggesting, for example, that those students who received a lecture presentation, utilized the printed notes made available to the COMIT people and vice versa.

Informal Characterization of Results

Extensive informal feedback was derived through conversations between students and professor/author, a means of communication specifically encouraged. The feedback has been subdivided into two categories, one representing those favourable toward the COMIT procedure and the second representing the unfavourable ones. Both of these categories of comments are listed along with some associated remarks within Tables 2 and 3, respectively. (These comments are felt to be self-explanatory and so will not be discussed at any length within the text in an explicit, enumerative way.) It is important, however, to isolate in particular the final three unfavourable comments about COMIT which represent what were perceived to be the most important criticisms of the utilization of the COMIT presentation. These unfavourable aspects were mentioned very frequently within the student-professor discussions. The implication of the three comments is the need for a presence of a professor when dealing with complex subject areas such as the problem of BOD. In other words, when students are being exposed to entirely new principles and concepts, the professor/class interaction as it should, and hopefully very often does occur, is very important to the learning process. Alternatively, when the nature of the learning process is more of reinforcement (and perhaps an awareness on the part of the student that the results of his efforts are being recorded and will be available to the professor), computer-aided teaching appears to have very considerable merit.

Table 2

Favourable Comments About COMIT

	Comment	Remarks
a)	COMIT is novel	Perhaps there is increased attention given by the student. Will the novelty wear off?
b)	Student can progress through the material at his/her individual rate.	
c)	Students can work in pairs and discuss elements of the material as it progresses.	This alternative was well-received by the students.
d)	COMIT requires examples to be done so that some learning is enforced.	It requires self-discipline, however, to avoid simply by-passing the material. The problem of by-passing is particularly relevant as time goes by.
e)	Elements of humour introduced occasionally into the text relieve the tedium.	
f)	With printed notes being made available, attention could be concentrated on the information rather than on the writing of notes.	The potential for distribution of printed notes exists for lectures as well as COMIT
g)	Use of colour and sophisticated graphics was noted as quite beneficial.	
h)	Students could return for review of the material at a future date.	This opportunity exists for the traditional lecture material as well via, for example, after-class student/professor discussions.

Table 3

Unfavourable Comments About COMIT

	Comment	Remarks
a)	Attention can only be held for a restricted time period. "How much COMIT exposure could you tolerate each day assuming it replaces lectures and other instructional modes"?	As the program progressed, interest diminished considerably and noticeable hurrying resulted.
b)	A tendency exists to try to read the material as it is presented on the screen	The information should be displayed immediately.
c)	In order to answer the questions posed, it is necessary to remember numerical values contained on previous slides.	
d)	The environment of the room is very important - noise from other students, people entering and leaving, etc. is very disruptive.	This difficulty can be corrected with appropriate design.
e)	It is inconvenient for the student to ask questions of the professor.	
f)	The student cannot benefit from the professor answering other student questions.	
g)	If a professor were asked to go over a point, he would cover it in a different manner than he had the first time - this tends to clarify the problem rather than just to restate it.	

Less than 1 hour	50%
1 - 2 hours	34%
2 - 3 hours	16%
More than 3 hours	0%

Conclusions

In a highly technical field, COMIT appears to be useful. The ability to demonstrate laboratory principles through graphical displays, the opportunity for students to progress at their own rate through the complicated material, and the availability of opportunities for review of material at a later date all suggest the considerable utility of COMIT in dealing with problems such as the introduction to BOD.

The above-indicated beneficial aspects of COMIT, however, do not appear to outweigh the detractions expressed both through numerical characterization (wherein no improvement in learning was observed with COMIT) and through informal feedback to the professor. In particular, the presence of the professor and thus the opportunity to receive answers to spontaneous questions, the ability to learn from the questions raised by fellow students and the ability to request further expansion of specific elements of the material, appeared to be serious detractors from the success of the COMIT utilization.

Overall, the benefits from COMIT utilization do not appear at this time to exceed those of the traditional lecture mode, in application to the problem of introducing relatively sophisticated environmental engineering concepts.

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Reference

Moore, J.B., and E.A. McBean, "A Comparison of the Effectiveness of Different Modes of Teaching", submitted to Journal of Computer-Based Instruction, 1978.